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The Impacts of Hurricane Andrew on Mangrove Coasts in Southern Florida: A Review

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ABSTRACT

SWIADEK, J.W., 1997. The impacts of Hurricane Andrew on mangrove coasts in southern Florida: A Review. *Journal of Coastal Research*, 13(1), 242-245. Fort Lauderdale (Florida), ISSN 0749-0208.

Coastal mangroves in Southern Florida were seriously damaged when Hurricane Andrew made landfall on August 24, 1992. Damage associated with Hurricane Andrew was primarily related to high wind velocity and surge. Shoreline erosion, which was generally less than 15 m, was caused by wave action and storm surge. This erosion may continue or expand since waves and currents can reprofile unprotected subsurface and intertidal sediments uprooted by mangrove trees.

ADDITIONAL INDEX WORDS: *Everglades National Park, Biscayne National Park, Everglades geology, mangroves, coastal erosion, storm surge.*

INTRODUCTION

Mangroves cover about 274,857 hectares around the southern coastal fringe of Florida, including Biscayne Bay, the Florida west coast, Whitewater Bay and Florida Bay (LUGO and SNEDAKER, 1974). They occur along the fringes of protected shorelines and islands, along river and creek drainages, around small low islands and low-lying promontories, and in inland areas along drainage depressions channeling terrestrial runoff toward the coast (LUGO and SNEDAKER, 1974).

There are three species of mangrove trees in this region: red mangrove (*Rhizophora mangle* L.), black mangrove (*Avicennia germinans* L.), and white mangrove (*Laguncularia racemosa* Gaertn.f.). Mangrove forests combine all four species and occur as mono-specific stands dominated by a single species (SFWMD, 1992). While the red and black mangroves are not rare enough to be classified as endangered species, they are listed as species of special concern by the state of Florida. The distribution of mixed and mono-specific forests is influenced by topographic and salinity gradients, lightning from thunderstorms, lumbering, and hurricanes. Mangrove forests have a limited and poorly developed understory because of their dense canopies (SFWMD, 1992). These understories include a variety of holophytic and freshwater species and the exact composition depends on local conditions (BURZYCKI, *personal communication*).

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Coastal mangrove forests protect hinterlands by absorbing storm waves (PETHICK, 1991). Coastal mangroves trap sediments and control erosion. When waves pass through the mangrove forest, their energy is dissipated inside the forest by the root system and trunks. The obstruction provided by the prop roots and trunks of the mangrove trees reduces wave velocity so that deposition of sediments rather than erosion tends to occur (BURZYCKI and DRUM, 1992). The coastal mangrove forest thus serves as a medium to focus sediment deposition on coasts which have low wave energy (BURZYCKI, *personal communication*).

METEOROLOGY OF HURRICANE ANDREW

The eye of Hurricane Andrew made landfall on 24 August at 0452 hours and about twenty-five miles south of downtown Miami near Florida City. An Air Force hurricane reconnaissance plane recorded sustained wind speeds of 300 km/hr and wind gusts of 315 km/hr at 3,048 meters elevation when Andrew approached the coast. Observations made by structural engineers and wind experts suggest that gusts may have exceeded 321 km/hr at ground level (SCHMIDT *et al.*, 1993). The highest confirmed wind speeds on land were 209 km/hr with gusts of 285 km/hr (POWELL and HOUSTON, 1993). Hurricane Andrew proceeded on a westerly course with a ground speed of about 25 km/hr, passing over Marco Island at 0730 hours before heading into the Gulf of Mexico and eventually impacting the Louisiana shore (SCHMIDT *et al.*, 1993) (see Figure 3).

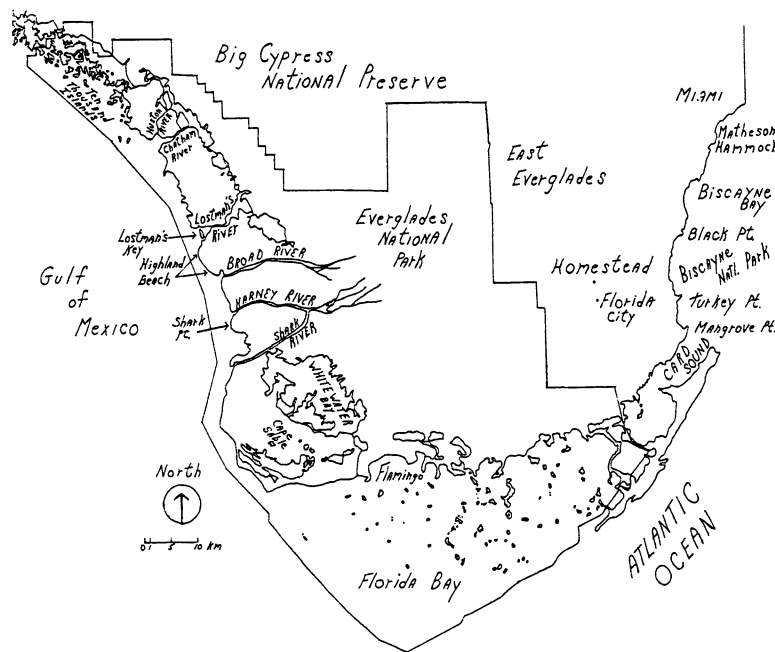


Figure 1. Schematic of Everglades National Park; modified from National Park Service map.

The behavior of the storm was similar to a 40 km wide tornado (OGDEN, 1992). FUJITA (1992) reported that vortices traveled in boomerang-shaped paths with winds of up to 321 km/hr (cited in SCHMIDT *et al.*, 1993). Maximum storm surges occurred around the eye wall and were approximately 6 m (PILKEY *et al.*, 1993). The total rainfall ranged from 101–152 mm depending on the location relative to the storm path.

COASTAL MANGROVE DAMAGE DUE TO HURRICANE ANDREW

Damage to mangrove forests was primarily wind induced (Plate 1). Hurricane waves produced comparatively little damage due to the low storm surge which was graphically restricted. The following factors minimized the impacts of the storm surge and wave action: (1) The coast is fronted by a reef flat. The undeveloped keys of Biscayne National Park acted as an offshore breakwater, substantially dampening the incoming wave energy (Figure 2). (2) On a larger scale, the Bahamas Island and carbonate shoals limited the fetch of hurricane-force winds. (3) Southeastern Florida has a very narrow continental shelf that mitigated the storm-surge (PILKEY *et al.*, 1993).

Shore Erosion

Storm surge and wave action caused less than 15 m of shoreline erosion (WANLESS, 1994). Assessment of shore erosion immediately after the hurricane is based on sedimentary deposits that were observed in late August through mid-September 1992. These deposits indicate the types of materials that were transported by Hurricane Andrew.

West Coast

On the broad intertidal to shallow subtidal banks seaward of Harney River, Broad River and Lostman's River, there was a widespread layer of mud and muddy sand up to 50 cm thick. In protected offshore depressions and interior bays, a grayish mud layer of approximately 20–50 cm thick was observed. This grey mud layer is indicative of quartz and calcium carbonate source material. No muddy storm deposits were observed on the seaward deepening offshore slope. Ebb deltas formed when surge waters receded from the mangrove swamp. These deltas formed along the west coast and along tidal channels as well as on Cape Sable (DAVIS *et al.*, 1992).

East Coast

In depressions along the western margin of Biscayne Bay, a tan to brownish sedimentary layer (up to 50 cm thick) was observed. In the mud banks and depressions on the east side of Biscayne Bay, a grayish mud layer of up to 50 cm thick was found. An ebb sand delta was reported about 3 km from the north end of Elliot Key on the eastern shore (DAVIS *et al.*, 1992).

There has been no subsequent subtidal erosion or storm deposition on the seaward side of the Safety Valve from Soldier Key southward as evidenced by clear waters in the area. The storm surge experienced on the Atlantic coast from Soldier Key to Elliot Key stripped away shore vegetation but had no effect on the limestone surface. The northern Safety Valve seaward coastal waters were highly turbid and of a whitish hue indicating erosion of coasts and banks as well as reworking of storm mud layers (DAVIS *et al.*, 1992).

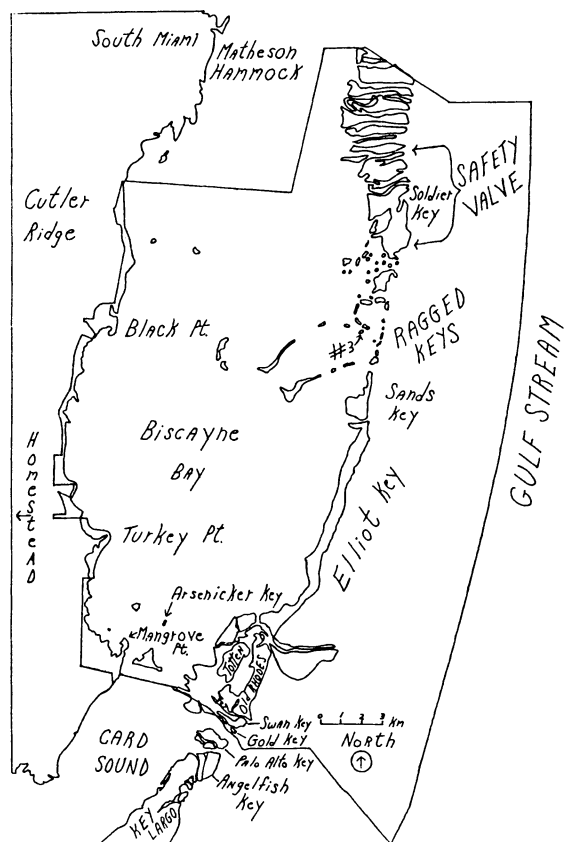


Figure 2. Schematic of Biscayne National Park; modified from National Park Service map.

In general, there was little erosion of peat and marl coastlines. High winds and storm surge uprooted trees creating approximately 1–2 m of local relief on forest floors in the areas that were hardest hit. It is anticipated that this coastal area will erode in response to wave and current exposure. This erosion may bring organic materials (such as dead twigs, decomposing leaves and tree stems) into the coastal bays (SMITH *et al.*, 1994).

The rough ground surface caused by the widespread tree uprooting, flattening of the mangrove forest now contains stagnant ponds and supratidal patches. This may be a precursor to being consumed by bay expansion as the sea level continues to rise (WANLESS, 1994).

MANGROVE RECOVERY

Impacts of Hurricane Andrew combined with human development may upset natural successional processes that will destabilize ecosystems in the region (TILMANT *et al.*, 1994). Recovery of Florida's mangroves is uncertain because some mangrove stands do not always return to their former state.

Prior to the 1935 hurricane, for example, a forest of black mangroves existed near Flamingo, Florida, but after the storm red mangroves became established and increased abundantly at that site. In 1960, Hurricane Donna destroyed

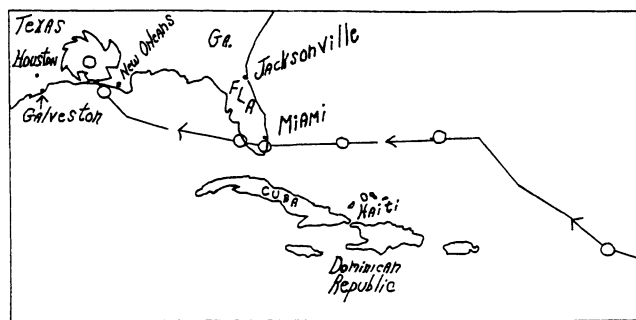


Figure 3. Path of Hurricane Andrew (SCHMIDT *et al.*, 1993).

mangrove forests along the northwest coast of Cape Sable, and the mangroves still have not recolonized large expanses of barren mudflats (SMITH *et al.*, 1994; CRAIGHEAD, 1971).

Several factors influence whether a mangrove forest will recover after a storm. For example, hurricane destroyed canopies show effects similar to those caused by lightning-induced canopy gaps. In comparison to the surrounding canopy, a gap has lower humidity and higher soil temperature (detrimental to mangrove seedlings) and increased light (beneficial to mangrove seedlings). In devastated mangrove areas, there are no longer living roots to aerate the soil and consequently there is a decrease in redox reaction. Anaerobic decomposition may increase the reduction of the surface level of peat soils (SMITH *et al.*, 1994).

Preliminary measurements of redoxomorphic processes indicate an increase in reduction as well as higher sulfide levels. Mangrove recolonization may be inhibited by sea-level rise as marine processes modify portions of the drowned mangrove substrate (WANLESS, 1994). It is still too early to ascertain the level of mangrove forest recovery from Hurricane Andrew (SMITH *et al.*, 1994).

CONCLUSION

In general, mangrove trees of less than 5 cm DBH (Diameter at Breast Height) had less than 10% mortality. Black mangroves had significantly lower mortality than red or white mangroves. Many trees which initially appeared to survive the hurricane (as evidenced by green leaves after the storm) eventually succumbed (SMITH *et al.*, 1994). Perhaps lightning helps to insure survival of the mangroves damaged by hurricanes because saplings have greater resiliency to hurricanes. As the sea level continues to rise, the devastated forest areas that do not recolonize could evolve into bays that deepen and expand (WANLESS, 1994).

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Plate 1. Hurricane damage to mangrove at Matheson Hammock. (A) Top left. Sprouting saplings and regrowth of upper tree foliage. (B) Top right. Widespread debris camouflages sapling sprouts. (C) Lower left. Storm surge as well as wind played a role in mangrove destruction. (D) Lower right. Widespread snapping of tree trunks is evident.

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